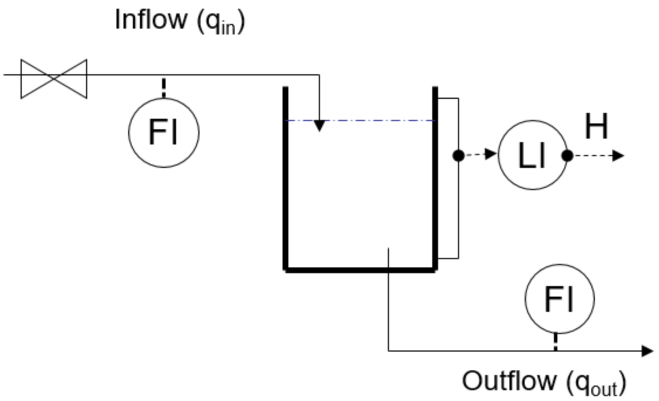
Exam 2017.

Level control (15%)



Consider level control using the inflow. We measure q_{in}, q_{out} [m^3/s] and H (level).

(a) Formulate the steady-state and dynamic material balance for the tank.
(b) Classify the variables with respect to control
(c) Suggest a control scheme based on feedforward control.
(d) Suggest a control scheme based on feedback control. What is the equation (algorithm) for a proportional controller?

Solution

(a) Assume constant liquid density.

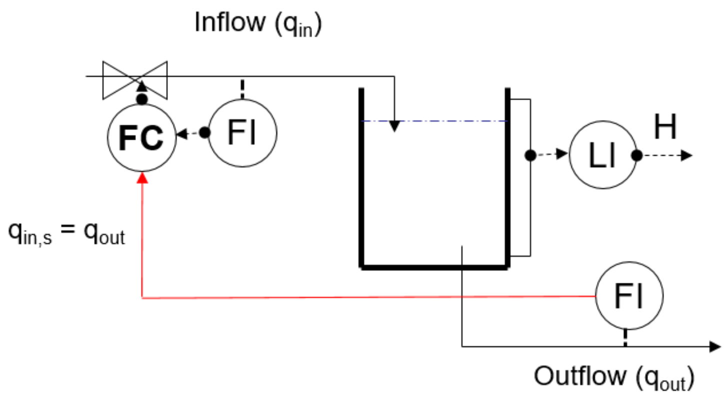
Steady-state mass balance: qin = qout   [m3/3]

Dynamic mass balance: dV/dt = qin – qout   [m3/s]

If we assume that the tank has constant area A [m2] then V=A*H, and dV/dt = A*dH/dt

(b) MV: qin, DV: qout, CV: H

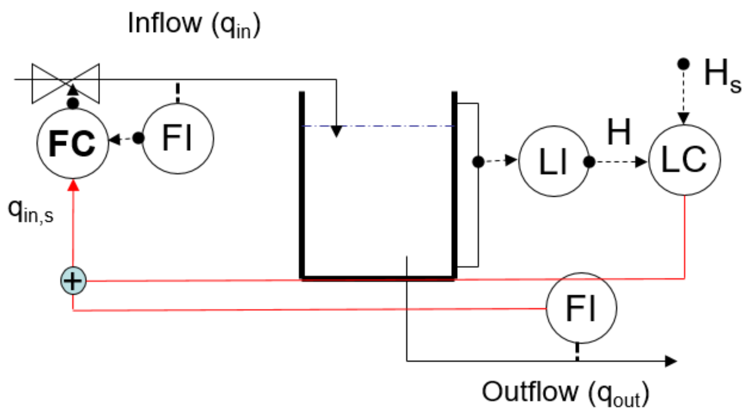
(c) Feedforward : Measure disturbance (qout) and change MV (qin).
Assume we want tight control of the level, then we want qin=quout because this makes dH/dt=0. To make qin=qout we may use a flow controller for qin with setpoint equal to qout. See Figure for feedforward



(d) Feedback: measure CV (H) and change MV (qin).

P-controller: u = Kc*(Hs-H) where u (=qin) is the output of the feedback controller

Comment (not asked for): We may also for the feedback use a flow controller, for example, to counteract disturbances in pin and linearize the valve. We may also combine feedback with feedforward control. See figure for combined feedback and feedforward:



More comments: 1) Actually, feedforward control cannot used alone for levels because otherwise the level will after some time drift away (integrating process). 2) This feedforward controller assumes that the objective is to have tight control of the level. In many cases the level should vary ("smooth" control") to avoid that the flow disturbance (here qout) propagates directly to the MV (here to qin).